ALTERNATIVE TECHNIQUES WHEN APPLYING SAFEGUARDS TO NATURAL URANIUM CONVERSION PLANTS

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I – ABSTRACT

The application of safeguards at Natural Uranium Conversion Plants (NUCP) has been traditionally based on the definition of the starting point of safeguards. Recently, there has been an increase interest in monitoring more points in the Uranium Conversion Plants to guarantee that all nuclear material produced by these plants are under safeguards.

To strength the safeguards applied to conversion plants, the IAEA has proposed a number of new safeguards measures that can be summarized in the IAEA Policy Paper 18th. In this Policy Paper an extensive consideration was done to the Nuclear Material suitable for enrichment and Fuel fabrication and a number of different diversion paths were analyzed.

Under the ABACC/IAEA system, the conversion plants for Brazil and Argentina have different process routes and the Quadripartite Agreement defines precisely where are the starting points of the safeguards and the requirements for any changes on these definitions. Some new measures proposed by the Policy Paper 18th are beyond the legal framework of the Quadripartite Agreement and sometimes may conduct to an additional inspection effort expended by the agencies and Operators, without having a profitable return.

Taking into consideration the necessity of strengthening the safeguards applied to these plants of the fuel cycle front end, ABACC, IAEA and National Authorities are discussing new alternatives measures to be applied to these Conversion Plants keeping the constraints and legal frames of the Quadripartite Agreement.

This paper presents a brief process description for the conversion plants within the ABACC system, makes considerations on the broad definition of starting point of safeguards based on new process technologies and their changes, and discusses the new measures proposed in order to strength the safeguards currently applied to the plants under the ABACC system, regarding their capacities, with the objective to improve the certainty that all pure nuclear material produced are under safeguards. The paper also discusses the effectiveness of having full accountancy and verification of the raw U3O8 material (Yellow Cake) that feed these plants.

II – INTRODUCTION

Traditionally, safeguarding natural uranium at a Natural Uranium Conversion Plant (NUCP) has not been a policy applied by IAEA because of the low intrinsic value of the natural uranium material. The starting point of safeguards was where the nuclear material reaches a point in which it is ready for enrichment or fuel fabrication. In NUCP plants the safeguards would start at production of pure uranium hexafluoride or oxides (UO2, U3O8) that have been the traditional starting points of IAEA.

However, with the development of new enrichment technologies and inside of the new concept that safeguards will look for undeclared activities and undeclared installations, the benefits of controlling purified natural uranium, in any point of NUCP processes, have become more important. The current International Atomic Energy Agency (IAEA) policy – Policy paper 18th - considers any purified aqueous uranium solution or any purified uranium oxides of a composition and purity suitable for isotopic enrichment or fuel fabrication inside the NUCP process being subject to safeguards control [1].

To control nuclear material inside a NUCP process is not always an easy task. NUCPs are typical chemical plants with huge pipes, big size equipment and tanks connecting among themselves and with a higher flexibility flow required by the process quality control and safety. Although a simple accounting system for assessing NUCP uranium inputs and outputs provides some assurance that undeclared material is not leaving the plant, this can not be considered as an efficient tool since the process efficiency is such that any change in values could cause uncertainty in the relation among inputs/output and will lead to process waste control which is even more cumbersome.

III – STRENGTHEN THE NUCP CONTROL

Looking at the diversion paths for pure nuclear material in NUCP we can elect the following scenarios:
1) Diversion of pure materials from declared feed for further processing or use elsewhere; and
2) Processing of undeclared feed to produce undeclared pure products (e.g., UF4, UO2, UF6)" [2].

From the scenarios above one should conclude that the strategic key points to apply safeguards in NUCP plants start in early stages of the process when the pure nuclear material is produced by the plant. If all nuclear pure material produced is safeguarded, the above scenarios would be covered. From the analysis of the NUCP process we conclude that the main critical location, where the nuclear material becomes pure, is on midway through the chemical process, usually after the production of pure uranyl nitrate solution. The production of uranyl nitrate is one step that almost all NUCP process goes through.

Controlling the other pure nuclear material downstream, such intermediate products like uranium dioxide (UO2), uranium tetrafluoride (UF4), and uranium hexafluoride (UF6), and all suitable uranium feedstock for producing special nuclear materials, it will be a more complex task, because after the main source of pure material the paths for nuclear material will have many derivatives ways and the control would be complex.

Based on the interpretation that the safeguards of the front end of the fuel cycle shall be enforced, IAEA establishes the Safeguards Policy Series 18 (Policy Paper 18th): "Safeguards Measures Applicable in Conversion Plants Processing Natural Uranium". This Policy Paper, combined with the new measures allowed by the Additional Protocol is dramatically changing the NUCP safeguards.

The main points stated in the Policy Paper 18th are:

- Interpretation of the nuclear material subject to safeguards (starting point), introducing the new definition of source material including the yellow cake in such category;
- New requirements for Design Information Provision and Verification;
- New DIV objectives; and
- Make use of a broad complementary access concept.

Combining with Safeguards Technical Report 342 (STR 342) - “Safeguards Approaches for NUCPs”, which regulates and indicates tools for applying safeguards at NUCPs, one should consider the following points [3]:

- As long as the nuclear material has reached the purity adequate for nuclear applications, even though it is an intermediate product on a process, it should be subject to safeguards control;
- It recognizes that the applications of safeguards to these intermediate products are sometimes unfeasible or not economically viable. It recommends that the safeguards shall be applied up to the process in order to guarantee the nuclear material control (going to upstream process phase up to yellow cake, if necessary).

IV – CONVERSION PLANTS UNDER QUADRIPARTITE AGREEMENT

In the system covered by the Quadripartite Agreement there are three large capacity conversion plants. In Argentina there are two conversion plants and in Brazil one, as below:

a) One that is located in Cordoba produces uranium dioxide (UO2) starting from Argentinean yellow cake or impure U3O8 (usually imported). The plant is operating and produces commercial material for the Argentinean nuclear reactors, with a designed capacity of 200 Ton/year;

b) The other plant in Argentina is located in Pilcaniyeu, Bariloche, and produces uranium hexafluoride (UF6) starting from pure UO2 already under safeguards. This plant is on shutdown status by now;

c) The plant in Brazil is located in Sorocaba, and produces uranium hexafluoride (UF6) starting from yellow cake. The plant process is the traditional wet route with uranyl nitrate being the first step of pure material. The present status of this plant is finalizing the construction and commissioning phase with a designed capacity of 40 Ton/year. This material will be used in the Brazilian enrichment program.

The Parties on the Quadripartite Agreement have not signed yet the Additional Protocol [4]. Taking into consideration that many activities and recommendations made by Policy Paper 18th and STR 342 are inside the scope of the Protocol mandate, it is beyond the current legal framework to apply directly the measures suggested by PP 18th. Furthermore, some points suggested on Policy Paper 18th and STR 342 have a high impact on the safeguards applications on NUCP and on the country.

Regarding the legal framework of Quadripartite Agreement, the main concerns identified in order to implement the Policy Paper 18th in the States Parties are:

- the change of the interpretation on source material (yellow cake) with the consequence of a new starting point definition for Natural Uranium safeguards which is viewed as a modification on the Agreement definition;
- The possibility of safeguards verification of the yellow cake, with activities like counting, identification and NDA or DA measurements.
- Includes the waste from the NUCP process phases, like filtration, before the purification process as a material subject to safeguards. It may have a consequence of storage these materials which will increase production costs and safety problems.

- Introduce a limitation on the waste management optimization and process recycling, since part of the material may have a control;
- The accountancy of the nuclear material, starting with yellow cake, will show significant differences as long as the material flows in the process, with consequences in the MUF values and its interpretation;
- Changes on the scope of the DIV verification that goes beyond the process phase that nuclear material is pure;
- Uses the complementary access which is inside the Protocol framework;

In addition, the inspection effort over a nuclear material of low strategic value could result substantially increased. The States Parties and ABACC agree in strengthening the safeguards on the front end of cycle, as long as the measures to be applied are inside the legal framework of the agreement.

V – SAFEGUARDS APPROACH PROPOSAL AND ALTERNATIVE TECHNIQUES

To control the pure material in the NUCP process in order to reduce the possibility of a nuclear material diversion, a safeguards approach shall take into consideration the following objectives:

1) Strengthen the control on the first step where the nuclear material becomes pure (pure uranyl nitrate), the acceptable starting point of safeguards under the current legal framework;
2) Have some control of the nuclear material on the process downstream, since all this material is pure and located in internal process phase;
3) Strengthen safeguards where the material will become under safeguards based on accountancy;
4) Use of any other safeguards tools to avoid diversion paths.

Based on the Policy Paper 18th and STR 342, and taking into account some elements of the Short Notice Random Inspection regime (SNRI), the following alternatives are being analyzed by the States Parties and ABACC.

1- For performing the control on the first step where the nuclear material becomes pure we have two basic alternatives;

a) To combine a short periodic operational declaration (mail box), with a retention period of the nuclear material to be verified on very short notice inspection or unannounced inspection. This will require that the Operator has enough plant capability to storage material during the retention period without interfering with plant operation. The combination of operator declaration with the unannounced inspection regime covers 100% verification of the production of pure nuclear material at the starting point of safeguards through the randomization introduced by this regime. On this alternative, some complementary surveillance and containment measures may be applied just before the retention storage point to strength the unannounced access and to deter diversion of nuclear material just before this point;

b) To make use of a flow monitor as soon as the material becomes pure. On this alternative, also some surveillance and containment measures may be applied to deter that nuclear material is neither diverted before this point nor the flow meter can be tampered. Special flow meters are presently being developed for this application. The impact of the process recycles must be considered when flow meter data is being used;

2 – To control the nuclear material downstream in the process up to key measurement point where the material is accounted and formally becoming under safeguards. There will be also two alternatives, as follows:

a) To apply surveillance and containment through the entire process. This is a very intrusive measure of difficult implementation, because the NUCP are very flexible plants and this safeguards tools will certainly interfere with the Operator procedure to run the plant. Besides, the cost versus benefits of this application should be carefully analyzed;
b) The other way is to make a comprehensive match of the records between the pure nitrate production and the first Key Measurement Point (KMP) where the material becomes accountable (UO2, UF4 or UF6). This may be enhanced with some intermediate process record comparison. To reduce the scenario of false operator declarations over the process, the comprehensive match should be complemented with a detailed DIV performed in this part of the plant on unannounced basis.

3- Strengthen safeguards where the material will become under safeguards based on accountancy. The best way is to create unpredictability on the safeguards verification. For doing that, the requirement of a short periodically operation declaration (mail box), with a retention period of the material, with unannounced inspection is proposed.

4- Other safeguards tools.
Since the plant is highly flexible and it may differ from process to process, the safeguards approach should look for points where extra control may be applied, without creating a heavy safeguards system. We can relate:

a) Consistency verification with any extra support document provided by the Operator. For instance, if the Agency/ABACC could get the UOC feeding material relation, a comparison between this support document and the periodic declarations for the pure uranyl nitrate would give the production rate and historical efficiency of the process;
b) Any Operator support document downstream in the process, between the pure nuclear material and the final plant output;
c) Containment and surveillance at specific points or equipment;
d) Samples for DA measurements to check the material background through impurities;
e) Enhanced DIV, as required, to evaluate changes on the plant either on the declared capacities or on feasible material take out points.

VI – A MODEL OF SAFEGUARDS APPROACH

We analyze here a broad safeguards approach proposed by ABACC to the conversion facility located in Córdoba, Argentina. (See IV-a).

This plant is currently in operation producing natural uranium, as UO2 final product. The process implemented at this facility covers all the steps to filtering and purifying uranyl nitrate liquors and the corresponding steps to adjust the concentration to precipitate pure ammonium uranyl carbonate and a subsequent reduction to UO2. After the reduction through the fluidized bed at high temperature, the pure UO2 is stabilized and collected in 200 L drums. The final product in this step is usually called “loads” and the nuclear material content will be confirmed after weighing and sampling. Once the results of the samples are available the drums are conditioned for shipment and transferred to the storage area. The material in the storage area usually has packing list available and is called “batches or lotes”. The “loads/cargas” are considered material in process and the “batches /lotes” are the final products.

In this facility, natural or low enriched uranium scrap recovery campaigns are scheduled once or twice a year linked with the country operational plans of the fuel fabrication plant. The feed material during these scraps campaign is already under safeguards.

The proposed approach combines the strengthening safeguards measures for the NUCP with the new Short Notice Random Inspection regime applied for domestic and international transfer verification at present under discussion with Argentina. ABACC considers important to:

1) Strengthen the control of the starting point of safeguards under the current legal framework (Pure uranyl nitrate) and cover the scenarios of diversion of pure nuclear material; and
2) Standardize the domestic and international transfer verification methodology.

To improve the safeguards effectiveness, and based on the alternative techniques presented above (item V), ABACC has opted for using very short notice inspection or unannounced inspection on inspections regimen instead of making use of an extensive surveillance system. This was because of the plant flexible characteristics would require a heavy surveillance system to monitor all routes and will not eliminate the necessity of DIV during the interim inspections. A comprehensive DIV, combined with nuclear material retention on chosen strategic measurement points, shall be done on an unannounced basis. However, the use of complimentary surveillance is not excluded, as the case of UO2 production area, to strength the unannounced access.

The inspections should be performed on unannounced basis and this regime would be supported by operational declarations through encrypted e-mail (electronic mail box). The unannounced inspections improve the effectiveness of the safeguards measures applied to the starting point of safeguards by introduction of deterrence.

The operational declaration should be done on periodic basis, preferably on weekly basis and should include the following information:

a. the pure uranyl nitrate production;
b. Information regarding UO2 produced in “loads”. This is accessible in process material and at the moment of the declaration this material has no packing list available. The operational declaration would include the total weigh of compound, the quantity of drums containing “loads” and their identification numbers.
c. Batches of UO2 produced during the week. The UO2 batches material is a final product and once it is in the storage this material is ready for shipment. The quantity of drums, the identification number and the total uranium should be declared through the encrypted e-mail. The packing list should be available for inspection purpose;
d. Forecast of the quantity of “loads” to be produced in the next week, expressed in weight of compounds and number of drums.
e. Monthly information (SNRI information by fax).
    i. Declaration of UO2 production;
    ii. Declaration of UOC feeding material.

Procedures should be adopted in order to assure that this information should be available for the Agencies on the first working day of the week. In addition, impure nuclear material (commercial U3O8, yellow cake) cannot be stored at the same place of safeguarded material.

The chosen retention strategic measurement points, coupled with the above declarations are listed below. The retention time has a direct relation with the declaration frequency (weekly or less), the Operator process limitation and the acting time of the Agencies in triggering the inspections.

a. For the pure uranyl nitrate production (alternates tanks of retention);
b. For the material on the loads produced during the week;
c. For the material declared as ready to be shipped (batches);

Based on the throughput or in the operational production declaration there could be an adequate number of unannounced SNRI inspection type, in which the following activities would take place:

a) Verification of against the declarations of the Pure uranyl nitrate production (retained tanks);
b) Take a DA sample on Pure uranyl nitrate production;
c) Verification of the UO2 material produced in "loads" and the final "batches", against the produced declarations and forecast. The shipping of this material can be carried out 7 days after the notification in the encrypted e-mail took place;
d) Accountancy and a consistency analysis between the quantities declared in points (Pure uranyl nitrate, "loads" and the final "batches", monthly UOC) to confirm that the plant operates as declared.

In addition, during UI the inspector should pass through those process steps where pure nuclear material is being processed (nitric solution concentration adjustment –AUC precipitation – UO2 reduction) in order to confirm the DIQ information and that no additional intermediate storages points were introduced.

The production schedule is Monday to Friday from 7am to 3pm. The unannounced inspection would be triggered during normal working hours. In addition, the inspector will pick up the last declaration before triggering the UI and should be able to arrive at the key strategic as soon as possible and no later than 2 hours.

The safeguards measures related with Scrap Recovery Campaigns have not been presented in the model approach. Regarding these campaigns, an additional number of unannounced SNRI inspections type with the same verification activities as above, plus domestic receipts verification and retention, and verification on the waste intended to be discharged as LD must be added to this model approach. Since all material in the process shall be under safeguards, the Operator would provide the Agencies the hold-up values for the beginning and ending of the campaign.

Taking into account the normal production of the facility is around 12 drums of 325 Kg of UO2 per week, under this scheme, ABACC and IAEA can follow the production of the facility on weekly basis with the option to confirm the operational declarations on unpredictable basis.

VI – FINAL REMARKS

ABACC has analyzed the safeguards measures applied under the current practice and, taking into account the new IAEA strength safeguards for NUCP, a model approach coupled with SNRI is presented. ABACC considers that this proposal:

- Strengthen the control on the first step where the nuclear material becomes pure (pure uranyl nitrate), without changing the interpretation of starting point of safeguards under the current legal framework of the Quadripartite Agreement;
- Provides nuclear material control on the process downstream, avoiding the expensive measures and interference on operational procedure;
- Strengths the safeguards measures where the material will become under safeguards based on accountancy;
- Introduce the use of other safeguards tools like DIV on short notice.

Another advantage of this scheme for the facility considered is that the scraps recovery campaigns would require only specific accounting procedures. It allows a broad access to the process steps and gives the chance to verify the operator declaration on completely unannounced basis. Accessible in-process materials are verified by NDA/DA measurements, as applicable, and the final product verified as required in the Safeguards Criteria without introducing any modification in the current legal framework of the Quadripartite Agreement.

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